Can the Matching Model Account for Spanish Unemployment?

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Abstract

This paper aims at explaining the dynamics of labor markets in Spain, especially the high persistence of unemployment and the Beveridge curve. We build a stochastic dynamic general equilibrium matching model, which assumes failures in the matching between vacancies and unemployed. We calibrate the model for the Spanish economy and simulate it considering two sources of exogenous shocks: a technological one and a reallocation one. The model is able to mimic the main stylized facts for the Spanish labor market. Moreover, we show that reallocation shocks are the main source that drive the labor market dynamics. We also analyze the dynamics of the Beveridge curve for Spain.

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1 Introduction

Although unemployment has been rising since the middle of the seventies in European countries, Spanish unemployment has attracted a greater deal of attention as it has been recognized to exhibit the largest rate. The Spanish labor market has shown several features that are different to those observed in the other countries, especially the persistence of high unemployment rates over the last two decades. Extensive research that tries to shed some light on the persistence of observed high unemployment rates exists[1].

Among others, Blanchard and Diamond (1989), Pissarides (1990) or Langot (1992), have shown that the Beveridge curve, the relationship between unemployment and vacancies, is very promising in explaining the dynamics of the labor market as well as the persistence of unemployment. The co–existence of vacancies and unemployment reflects the existence of imperfections in the labor market, such as coordination failures among economic agents. As Antolín (1994) or Dolado and Gómez (1996) remark, the Spanish Beveridge curve is similar to the ones of other European countries. However, that the outward shift of the Beveridge curve that took place in Spain during the 80's is characterized by a greater magnitude compared to other European countries.

The goal of this paper is to analyze the labor market's cyclical properties. In the literature these cyclical properties have widely been explored. Kydland and Prescott (1982) admit that more has to be done in the RBC literature in order to explain the labor market's stylized facts. Many extensions and variations have been tried, such as assuming indivisible labor (Hansen (1985)). In our article, we deal with the matching framework defined in Pissarides (1990) which proposes a model in which the allocation process in the labor market is imperfect: due to costs and coordination failures, vacancies and unemployment co–exist; two main characteristics of the Spanish economy. The matching model allows to differentiate between technological shocks (movements along the Beveridge curve) and reallocation shocks (shifts of the Beveridge curve itself). Following this motivation some empirical work has been applied to the Spanish economy. Antolín (1994) analyzes unemployment inflows and outflows and the causes behind the outward shift of the Beveridge curve. He concludes that unemployment seems to be quite structural, and that changes in job search intensity may explain the unemployment problem. Dolado and Gómez (1996) study the dynamic behavior of the Beveridge curve at the aggregate level as well as at the regional level. They conclude that technological shocks and reallocation shocks play a very important role in the outward shift of the Beveridge curve. Sneessens, Fonseca and Maillard (1998) examine the outward shift of the Beveridge curve in Spain through skill and regional mismatch, showing that the structural component of unemployment is highly significant.

[1] See, i.e., Bentolila and Blanchard (1990), Blanchard et al. (1995) and Dolado and Jimeno (1997)

In order to deepen the empirical discussion we develop a theoretical benchmark model for Spain. Following Langot (1992) and Mertz (1995), we build a stochastic intertemporal general equilibrium model which generates persistent unemployment. The wage setting is modelled as an individual Nash bargaining process. We introduce two different types of shocks: technological and reallocation ones. The former accounts for temporary changes in productivity, whereas the latter accounts for changes in the hiring process. The assessment of our model is done in terms of its ability to replicate main labor market moments as well as to replicate the Beveridge curve for the Spanish economy.

The outline of the paper is as follows: in the next section we present the model. In section 3 we describe the data and the calibration procedure. Section 4 presents the stylized facts and our quantitative results as well as the dynamics of the model and its ability to replicate the Beveridge curve. Finally, section 5 concludes and presents some possible extensions.

2 The model

We first describe the matching model. Next, we present the maximization problem of the firm and the households. Finally, we describe the labor contract.

2.1 Trade on the labor market

Following Pissarides (1990) we assume that trade in the labor market is an uncoordinated and costly activity. At the beginning of the period the firm posts some vacancies, V_t; to fill at a cost ω: N_t is the number of workers at the beginning of period t and $U_t = 1 - N_t$ is the number of unemployed[2]. We assume that only unemployed workers can apply to a posted vacancy. Coordination failures imply that the match, H_t, is not perfect, but rather represented by the following aggregate matching function with constant returns to scale:

$$H_t = m_t H_o V_t^{\gamma} U_t^{1-\gamma}$$

where γ represents the elasticity of hirings with respect to vacancies, and H_o is a scale factor. m_t is a variable which measures the reallocation shock, the efficiency of the matching function to create new hirings. This variable evolves according to the following process:

$$\log m_t = \rho_m \log m_{t-1} + (1 - \rho_m) \log \bar{m} + \varepsilon_{m;t}$$

with the autocorrelation term $|\rho_m| < 1$ and the standard error of the shock distributed as $\varepsilon_{m;t} \sim N(0; \sigma_m)$:

[2] As the number of households is normalized to one, the employment rate is denoted by N_t and the unemployment rate by U_t. In order to keep the same notation, V_t is the vacancy rate.

The probability of an unemployed finding a job is given by $p_t = \frac{H_t}{U_t}$. The probability of the firm filling a vacancy is $q_t = \frac{H_t}{V_t}$. These two probabilities are functions of the tightness on the labor market, measured as the ratio of vacancies to unemployment, $\theta_t = \frac{V_t}{U_t}$.

The law of motion of aggregate employment is given by:

$$N_{t+1} = (1 - s)N_t + H_t$$

where $s \in (0;1)$ is the exogenous separation rate of employment — i.e. the probability of a worker losing its job.

2.2 The firm

We assume a continuum of firms, denoted by j; with measure one. All firms have access to the same technology represented by the following Cobb–Douglas function:

$$Y_{j;t} = A_t K_{j;t}^{\alpha} N_{j;t}^{1-\alpha}$$

where $K_{j;t}$ denotes capital and A_t denotes the aggregate technological shock which follows the stochastic process

$$\log A_t = \rho_A \log A_{t-1} + (1 - \rho_A) \log \overline{A} + \varepsilon_{A;t}$$

with the autocorrelation term $|\rho_A| < 1$ and the standard error of the shock distributed as $\varepsilon_{A;t} \sim N(0; \sigma_A)$:

The period t instantaneous profit is given by

$$\Pi_{j;t} = A_t K_{j;t}^{\alpha} N_{j;t}^{1-\alpha} - w_t N_{j;t} - I_{j;t} - \omega V_{j;t}$$

where ω summarizes the search and recruiting costs associated to post vacancies, w_t is the real wage and $I_{j;t}$ denotes investment.

Each firm j maximizes the expected discounted sum of its profit flows over $I_{j;t}$ and $V_{j;t}$, which can be recursively stated as

$$V(S_{j;t}^F) = \mathrm{Max} \left\{ \Pi_{j;t} + \int_Z \rho(z=z_t)\, V(S_{j;t+1}^F) dz \right\}$$

where $V(S_{j;t}^F)$ is the value of a firm subject to the law of accumulation of capital and labor:

$$\begin{aligned} K_{j;t+1} &= I_{j;t} + (1 - \delta) K_{j;t} \\ N_{j;t+1} &= q_t V_{j;t} + (1 - s) N_{j;t} \end{aligned}$$

The possible state of nature is denoted by $z_t = (A_t, m_t)$, which belongs to set Z and $S^F_{j,t} = \{K_{j,t}, N_{j,t}, z_t\}$ is the set of each firm's state variables, $\{\rho(z|z_t)\}_{t=0}^{\infty}$ is the pricing kernel and $X^K_{j,t}$, $X^N_{j,t}$ are the multipliers associated to the laws of accumulation of capital and labor, respectively[3].

2.3 The households

We assume a continuum of households, denoted by i, with a measure of one. At each time t they can, either be employed, with probability N_t, or be unemployed, with probability $U_t = 1 - N_t$. Depending on the state, the instantaneous utility function of the consumer i takes values:

$$U^n_{i,t} = \log(C^n_{i,t} - \Gamma^n)$$
$$U^u_{i,t} = \log(C^u_{i,t} - \Gamma^u)$$

where $U^n_{i,t}$ and $U^u_{i,t}$ are the respective utility functions for employed and unemployed households. $C^n_{i,t}$ and $C^u_{i,t}$ the respective household's consumption and Γ^n and Γ^u represent a cost, in terms of physical goods, associated to be employed or unemployed, respectively. We assume that $\Gamma^n > \Gamma^u$ and that both costs are constant along the business cycle.

We define the probability of finding a job as the probability of being employed, N_t. The problem of the representative household i is to maximize the expectation of the discounted sum of its instantaneous utility with respect to consumption and the assets it holds:

$$W(S^N_{i,t}) = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ N_t U^n_{i,t} + (1 - N_t) U^u_{i,t} \right\}$$

subject to the constraints:

$$N_t C^n_{i,t} + (1 - N_t) C^u_{i,t} + \int \rho(z|z_t) B_{i,t+1}(z)\,dz \leq N_t w_t + B_{i,t}$$

$$N_{t+1} = (1 - s)N_t + p_t(1 - N_t)$$

The right-hand-side of the first constraint expresses the revenues of the households, who earn the wage when employed and receive $B_{i,t}$, the bonds they accumulated in the previous period. The left-hand-side expresses the households' expenditures, which consists of consumption and the amount of bonds to hold for the next period. Implicit in this formulation is a perfect insurance system that allows households to accumulate the same level of bonds whatever their situation on the labor market is[4]. Finally, the second restriction summarizes the evolution of aggregate employment.

[3] Appendix A shows the Euler conditions for the firm's problem.

[4] A more detailed description is shown in Appendix B.

2.4 Wage determination

We assume that each firm and each employee bargain on the labor contract. The solution criterion chosen is the Nash bargaining process as proposed by Pissarides (1990). Whenever there is a match in the labor market, the employee and the firm first bargain over the wage, the firm then demands labor in a "right-to-manage" process.

Let $0 < \xi < 1$ denote the household's share of the total marginal value of a new job, and hence its bargaining power. The Nash bargaining criterion maximizes over wages the marginal value of a job match for a representative firm, $\Omega^F_{j;t}$, and household, $\frac{\Omega^N_{i;t}}{\Lambda_{i;t}}$[5]:

$$\operatorname{Max}\left\{\left(\Omega^F_{j;t}\right)^{1-\xi}\left(\frac{\Omega^N_{i;t}}{\Lambda_{i;t}}\right)^{\xi}\right\}.$$

The marginal value of a job match for the representative household is given by:

$$\Omega^N_{i;t}=\frac{\partial W(S^N_{i;t})}{\partial N_t}=\Lambda_{i;t}(w_{i;t}+\Gamma^u-\Gamma^n)+[1-s-p_t]\beta E_t\frac{\partial W(S^N_{i;t+1})}{\partial N_{t+1}}$$

where $\Lambda_{i;t}$ is the Lagrange multiplier associated to the budget constraint of the representative household, which corresponds to the marginal value of wealth. $w_{it}+\Gamma^u-\Gamma^n$ is the optimal choice of unemployment insurance. Symmetrically, for firm j the marginal value of a job match is given by:

$$\Omega^F_{j;t}=\frac{\partial V(S^F_{j;t})}{\partial N_t}=(1-\alpha)\frac{Y_{j;t}}{N_{j;t}}-w_t+(1-s)\int_z\rho(z/z_t)\frac{\partial V(S^F_{j;t+1})}{\partial N_{j;t+1}}dz.$$

The first order condition of the Nash bargaining criterion states that

$$\Omega^F_{j;t}=\frac{1-\xi}{\xi}\left(\frac{\Omega^N_{i;t}}{\Lambda_{i;t}}\right)$$

in which we substitute $\frac{\Omega^N_{i;t}}{\Lambda_{i;t}}$ and $\Omega^F_{j;t}$ by their previous expressions. Assuming symmetric equilibrium, $i=j$, and rearranging the equation we obtain the evolution of wages:

$$w_{i;t}=\xi\left[(1-\alpha)\frac{Y_{j;t}}{N_{j;t}}+p_tX^N_{j;t}\right]+(1-\xi)\left[(\Gamma^n-\Gamma^u)\right]$$

[5] Following Andolfatto (1996), $\frac{\Omega^N_{i;t}}{\Lambda_{i;t}}$ express the marginal value of a job match for the household measured in units of goods. It implies that both the firm's and household's marginal values are expressed in the same units.

The wage is determined by a rent sharing mechanism which depends on the bargaining power of each agent. The firm acquires the gain in labor productivity plus the discounted marginal value of a new job times the probability p_t of finding it. The share the employee gains is the difference in terms of cost of being employed compared to being unemployed.

It is also worth noting that wages and productivity follow close but different processes, which is a novelty of the proposed models compare to the standard business cycle model. This comes from the way wages are set, i.e. via the bargaining process, which depends mainly on labor productivity but also on the net value of a new hiring and differences in consumption. We remark that wages are highly procyclical since they are mainly based on productivity changes, while the share the employee gains is constant over time[6].

3 Data and Calibration

Assessing models consists in comparing their results with those of the actual economy. The measures obtained from the actual data must be rearranged to be consistent with our model. We describe first the data, then the calibration of the model.

3.1 The data

All series are quarterly for the period 1977:1-1994:4. Puch and Licandro (1997) elaborate on the National Accounts of the Spanish Economy (Contabilidad Nacional de España) to divide consumption into durable and non-durable consumption. Following this definition we define consumption as the sum of non-durables plus government expenditures, investment as the sum of durables plus original investment. Finally, we define output as the sum of consumption and investment.

Vacancy data are obtained from Antolín (1994) who corrects vacancy data from the Employment National Office (INEM) to take into account vacancies which are privately advertised. Employment and unemployment data are obtained from the Labor Force Survey (EPA).

3.2 Calibration

The Euler equations at the symmetric equilibrium as well as the equilibrium conditions are log-linearized around the steady-state of the economy. The log-linearized model is then solved following Farmer (1994).

Values must be assigned to the structural parameters in order to compute the model's equilibrium. Given information about aggregate variables and external

[6] The fact that this share is constant over time implies that the wage equation is independent of the marginal utility of consumption. This comes from our specification of the utility function and full unemployment insurance.

information, as well as the equations of the model in the steady state, we use the restrictions imposed by the theory.

The separation rate, s, is kept constant and calibrated by referring to Antolín (1997) who estimates this value for the Spanish economy with quarterly data from the period 1977-1996. This separation rate is quite low as it remained at very low levels until 1987.

The ratio of recruiting expenditures to output, $\frac{\omega V}{Y}$, is the ratio of hiring costs to total output. It is assumed to be 1% in the steady state. wn/Y is the share of labor in a competitive equilibrium model with a Cobb-Douglas production function. We use the estimate of Puch and Licandro (1997) to calibrate this ratio. The tightness in the labor market, θ, is the ratio of vacancies to unemployment.

Table 1: Ratios and Probabilities

s	$\omega V/Y$	N	U	V	$\frac{K}{Y}$	$\frac{I}{Y}$	$\frac{wn}{Y}$	θ
0.0203	0.01	0.83	0.17	0.0062	9.85	0.29	0.6529	0.0368

Castillo et al. (1998) estimate a Cobb-Douglas matching function with constant returns to scale for the Spanish economy. From their estimations we take the elasticity of hirings with respect to vacancies to be $\gamma = 0.15$. We assume that the decentralized equilibrium is an optimum, thus $\xi = 1 - \gamma$. To simplify, we assume that the cost of being unemployed, Γ^u, is zero. The depreciation rate of capital, δ, is found from the ratio i/k. The share of capital in the production function, α, the cost of working, Γ^n, and the personal discount rate, β, constitute a solution to the system of equations in the steady state.

Table 2: Parameters of the model

α	β	δ	γ	ξ	Γ^n	Γ^u	ρ_A	σ_A	ρ_m	σ_m
0.3348	0.9952	0.0292	0.15	0.85	0.7073	0	0.9588	0.007	0.7	0.12

The parameters corresponding to the technological stochastic process are estimated from the Solow residual

$$\log A_t = \log Y_t - \alpha \log K_t - (1 - \alpha) \log n_t,$$

which evolves as

$$\log A_t = \rho_A \log A_{t-1} + (1 - \rho_A) \log \overline{A} + \varepsilon_{A,t}.$$

From this AR(1) process we estimate the autocorrelation parameter, ρ_A, and the standard deviation of the shock, σ_A. To complete the calibration we estimate the parameters of the reallocation process, ρ_m and σ_m, such that the model is able to reproduce the autocorrelation and the relative standard deviation of employment in the data.

4 Can the model account for the Spanish labor market?

This section is devoted to the analysis of the implications of our model economy in terms of the Spanish business cycle on the labor market. Table 3 reports some stylized facts for the Spanish economy as well as the same set of moments computed using the models we investigate. Model I refers to the standard matching model with a technological shock, model II refers to the previous matching model with an additional reallocation shock.

Table 3: Second Order Moments and Correlations

	Spanish Data		Model I		Model II	
	(1)	(2)	(1)	(2)	(1)	(2)
c	0.73	0.93	0.39	0.97	0.48	0.94
i	2.48	0.94	2.51	0.99	2.44	0.98
n	0.74	0.86	0.01	0.23	0.74	0.48
u	3.13	-0.73	0.07	-0.23	3.73	-0.48
v	10.37	-0.02	1.45	0.99	12.79	-0.04
prd	0.53	0.69	1.00	0.99	0.91	0.70

(1): relative standard deviation with respect to output

(2): present correlation with output

Model I fails to account for most of the relative standard deviations and also fails in the contemporaneous correlation of vacancies with output, which is high and positive in the model while the actual data displays no correlation. These results are standard in similar models of matching, i.e. Langot (1992), due to a transmission mechanism of the shock which is not su¢cient to replicate the labor market. As usual in the literature, model II includes a reallocation shock, m_t; that improves the model's ability to mimic the moments. The reallocation shock implies a higher transitory productivity in hirings. Notice that in order to calibrate the reallocation shock we have imposed that it has to reproduce both the relative standard deviation and the autocorrelation of employment (0.74 and 0.91, respectively). The introduction of a new shock which directly a¤ects the labor market allows us to reproduce the stylized facts of the Spanish economy in a closer way. This especially improves the moments related to vacancies, reproducing the correlation between output and vacancies.

We now investigate the ability of the model to account for the dynamics of the Spanish labor market. Table 4 reports the correlations of vacancies and unemployment at leads and lags.

Table 4: $Corr(V_t; U_{t+j})$

Period	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
Data	-.07	-.17	-.12	-.09	-.26	-.30	-.20	-.04	-.09
Model I	-.73	-.73	-.65	-.48	-.19	.02	.19	.31	.38
Model II	-.51	-.50	-.41	-.19	.23	.45	.53	.52	.47

The data show that the Spanish economy displays a Beveridge curve. Unemployment lags vacancies along the cycle — i.e. when the firm finds it profitable to create a job, it increases vacancies. Hence the number of hirings increases some periods later, reducing unemployment. However, absolute values are not too significant and the maximum value is found at period $t+1$. The instantaneous correlation is negative, which implies an immediate adjustment to the shock, yet correlations in $t+1$ and $t+2$ show that firms recruit workers for two more periods. This result is similar to that obtained with models in which the production function has adjustment costs in labor and shows the lasting effect of a shock in the labor market.

The lag and lead correlations of vacancies and unemployment given by model I are far form those obtained from actual data although are better than those obtained from model II. Only model I is close to the actual instantaneous correlation of vacancies and unemployment. In Figure 1 (see Appendix C), we plot the correlations between vacancies and unemployment and observe that in both models they have the same shape, both have negative correlations for leads and positive ones for lags. However, model II always has a higher correlation between vacancies and unemployment. These results imply that none of the models are able to replicate the Beveridge curve for the Spanish economy as the transmission mechanism is too dependent on the correlations between vacancies and unemployment for leads and lags. This result is a standard feature shared by most of the existing matching models. Indeed, the reallocation shock is introduced as a productivity shock in the matching function. In fact, we are explaining the dynamics of the Beveridge curve around the steady state without taking into account possible, and plausible, shifts of the Beveridge curve itself. These shifts are explained in the Spanish literature as hysteresis (Dolado and Gómez, 1996) or structural changes in the labor market (Sneessens, Fonseca and Maillard, 1998). As a consequence, the model neglects part of the Beveridge curve changes and only focuses on the short-term dynamics.

In order to provide the reader with a better understanding of the transmission mechanisms that underlie the models, we report in figures 2 and 4 (see Appendix C) the impulse response functions (IRF) of unemployment, vacancies, wages and the tightness of the labor market, μ; to a technological and a reallocation shock.

A technological shock implies an increase in the productivity. As the firms know that the shock will last for more periods, they increase their vacancies in order to increase future employment. The labor adjustment is not contemporaneous as it takes at least one period to hire. This implies a reduction in unemployment from the second period onwards. The effects on vacancies and unemployment induce a rise in the tightness of the labor market, μ; which increases the probability of an unemployed finding a job whilst reduces the probability of firms to fill a vacancy. Wages represent in this model the rent that a new job creates. As the productivity of labor increases, so does the rent. Thus wages deviate from the steady state for the contemporaneous period. It is noteworthy that the technological shock is persistent and that the steady state level of the variables is reached more than two hundred periods later. Figure

3 (see Appendix C) displays the dynamics around the Beveridge curve of the model after a technological shock. After a technological shock firms increase the number of vacancies they post but unemployment does not fall as hirings take time. In subsequent periods, firms reduce the number of vacancies posted and increase the hirings, which reduces unemployment. After some periods the number of vacancies posted as well as the number of hirings keeps falling as the shock implies less productivity and hiring is less profitable. Finally, the dynamic of the variables returns to the initial steady state level.

A reallocation shock implies the need for higher efficiency in order to fill a vacancy. Given the vacancies posted, firms are able to hire more workers, reducing unemployment. As the firms know that the effects of the shock will last for some periods, they carry on posting vacancies. After around fifteen periods the tightness of the labor market returns back to its steady state level. This kind of shock does not affect productivity, and hence wages, and has a shorter effect on the labor market variables than the technological shock. It also implies a lower deviation of the variables from their steady state levels. We also investigated the effects of a permanent reallocation shock, but found that it does not significantly improve the results.

When both shocks are computed together, the impulse-response functions of unemployment and vacancies for each shock go in opposite directions after several periods. This reduces the correlation of vacancies with output and increases its volatility. Given our calibration, the reallocation shock always dominates the dynamics, in the short as well as in the long run. In fact, it accounts for more than ninety per cent of the labor market variables after five hundred periods.

We have also tested different degrees of substitution for a matching function exhibiting a constant elasticity of substitution[7]. Except for the required standard deviation of the shock of matching the results are not substantially altered. On the one hand, for low degrees of substitution we need a lower standard deviation of the matching shock, which implies complementarity between vacancies and unemployment. On the contrary, for high degrees of substitution, the required standard deviation of the matching shock to replicate the persistence of employment is unacceptably high.

Although the reallocation shock is able to improve upon some of the results of the Beveridge curve, the calibration chosen implies that the standard deviation of the reallocation shock is around seventeen times larger than the one of the technological shock. This would imply that the main source of variability in the Spanish labor market is changes in the efficiency of hirings. Changes in sectors, skills or education could have motivated differences in the matching process. However, none of these models is able to reproduce the correlation between vacancies and unemployment, the Beveridge curve, very well, especially as structural or macroeconomic changes are not taken into account. Our results

[7] The use of a Cobb-Douglas matching function with constant returns to scale is still controversial. Castillo et al. (1998) find constant returns to scale of the matching function for Spain. On the contrary, Bell (1997) finds increasing returns to scale for the matching technology in the Spanish economy. Antolín (1994) concludes that he could not reject the hyphotesis of increasing returns to scale in the flows of vacancies and unemployment.

are similar to previous models with matching functions and re‡ect the need of additional improvements of the model to be able to fully explain the Beveridge curve.

5 Conclusions

Our purpose in this paper is to build a stochastic intertemporal general equilibrium model of matching for the Spanish economy. The model is consistent with the main features of the actual economy and reproduce the main stylized facts of the labor market.

We …rst introduce a matching model with a technological shock and …nd that it does not explain the main moments of the Spanish economy. Following the related literature, we introduce an additional reallocation shock in the matching function, and …nd a large improvement of the results.

Our main …nding is that the model with both kinds of shocks is able to reproduce the labor market moments, especially those related to vacancies. However, it fails to account for the Beveridge curve, which could be due to the way the reallocation shock is introduced or, more plausibly, by shifts of the Beveridge curve caused by structural or macroeconomic changes in the labor market.

Our model does not fully explain the Spanish labor market as the matching model only focusses on the vacancy-unemployment relationship without taking structural features into account. However the main conclusion we obtain is that the labor market seems essentially to be able to account for the business cycle of the last 20 years in Spain.

In order to improve upon the previous results we have tested alternative assumptions. We have introduced complementarity in the matching function through a constant elasticity of substitution. Using di¤erent elasticities, we have found that the results are not largely improved upon although the standard deviation of the required matching shock is reduced. This could imply a type of complementarity between both vacancies and unemployment in the matching function. Testing the form of the matching function in Spain seems to be an interesting extension in order to clarify all these aspects.

The model could also be extended to take ‡ows in and out of the labor market into account. Firms should have to endogenize the departure rate in order to obtain an optimal in‡ow and out‡ow from the labor market. This could then be compared to actual data.

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7 Appendix

7.1 Appendix A: Decisions Rules of Firm j:

Each firm j maximizes the expected discounted sum of its profit flows over $I_{j;t}$ and $V_{j;t}$, which can be recursively stated as

$$V(S^F_{j;t}) = Max \left\{ \Pi_{j;t} + \int \rho(z/z_t) V(S^F_{j;t+1}) dz \right\}$$

where $V(S^F_{j;t})$ is the value of a firm, subject to the law of accumulation of capital and labor

$$\begin{aligned} X^K_{j;t} &: \quad K_{j;t+1} = I_{j;t} + (1-\delta)K_{j;t} \\ X^N_{j;t} &: \quad N_{j;t+1} = q_t V_{j;t} + (1-s)N_{j;t}. \end{aligned}$$

The first order conditions of the control variables are

$$\begin{aligned} /I_{j;t} &: \quad 1 = X^K_{j;t} \\ /V_{j;t} &: \quad X_{j;t} = \frac{\omega}{q_t} \end{aligned}$$

and the first order conditions of the state variables are

$$\begin{aligned} /K_{j;t} &: \quad V'_{j;K}(t) = \alpha \frac{Y_{j;t}}{K_{j;t}} + (1-\delta)X^K_{j;t} \\ /K_{j;t+1} &: \quad \int \rho(z/z_t) V_{j;K}(t+1) dz = X^K_{j;t} \\ /N_{j;t} &: \quad V'_{j;N}(t) = (1-\alpha)\frac{Y_{j;t}}{N_{j;t}} - w_t + (1-s)X^N_{j;t} \\ /N_{j;t+1} &: \quad \int \rho(z/z_t) V_{j;N}(t+1) dz = X^N_{j;t} \end{aligned}$$

which imply the following intertemporal conditions:

$$\begin{aligned} 1 &= \int \rho(z/z_t) \left(\alpha \frac{Y_{j;t+1}}{K_{j;t+1}} + 1 - \delta \right) dz \\ X^N_{j;t} &= \int \rho(z/z_t) \left((1-\alpha)\frac{Y_{j;t+1}}{N_{j;t+1}} - w_{t+1} + (1-s)X^N_{j;t+1} \right) dz \end{aligned}$$

7.2 Appendix B: The consumer problem with full-insurance

Each household maximizes the expected intertemporal utility function

$$W(S^N_{i,t}) = E_0 \sum_{t=0} \beta^t \left\{ N_t \log(C^n_{i,t} - \Gamma^n) + (1 - N_t) \log(C^u_{it} - \Gamma^u) \right\}$$

where N_t is the probability for an agent to work at time t; consumption when the household is employed and unemployed is denoted by $C^n_{i,t}$ and $C^u_{i,t}$ respectively. Γ^u and Γ^n are the cost in terms of physical goods of being unemployed and employed respectively. We assume that $\Gamma^n > \Gamma^u$.

We maximize $W(S^N_{i,t})$ subject to the constraints corresponding to each state of the labor market (respectively employed and unemployed):

$$C^n_{i,t} + \tau_t A_{i,t} + \int \rho(z/z_t) B^n_{i,t+1}(z)dz \leq B^n_{i,t} + w_{i,t}$$

$$C^u_{i,t} + \tau_t A_{i,t} + \int \rho(z/z_t) B^u_{i,t+1}(z)dz \leq B^u_{i,t} + A_{i,t}$$

where τ_t is the price of the insurance contract, $A_{i,t}$ is the insurance, which is the same for both employed and unemployed households, and $B^n_{i,t}$ ($B^u_{i,t}$) denotes bonds accumulated when the household is employed (unemployed).

The first order conditions with respect to $C^n_{i,t}$, $C^u_{i,t}$, $A_{i,t}$, $B^n_{i,t}$ and $B^u_{i,t}$ are the following

$$\begin{aligned}
C^n_{i,t} &: (C^n_{i,t} - \Gamma^n)^{-1} = \lambda^n_{i,t} \\
C^u_{i,t} &: (C^u_{i,t} - \Gamma^u)^{-1} = \lambda^u_{i,t} \\
A_{i,t} &: -N_t \tau_t \lambda^n_{i,t} - (1 - N_t)(1 - \tau_t)\lambda^u_{i,t} = 0 \\
B^n_{i,t} &: \rho(z/z_t)\lambda^n_{i,t} = \beta \lambda^n_{i,t} f(z/z_t) \\
B^u_{i,t} &: \rho(z/z_t)\lambda^u_{i,t} = \beta \lambda^u_{i,t} f(z/z_t)
\end{aligned}$$

where $\lambda^n_{i,t}$ ($\lambda^u_{i,t}$) is the Lagrangian multiplier associated to the budget constraint when the household is employed (unemployed).

7.2.1 Insurance Company

The insurance company maximizes its profits such that income is equal to costs:

$$\Pi = \tau_t A_{i,t} - (1 - N_t) A_{i,t} = 0$$

The solution is $\tau_t = 1 - N_t$.

If we substitute this result in the first order conditions of insurance, we obtain:

$$\Lambda_{i,t}^{n} = \Lambda_{i,t}^{u} = \Lambda_{i,t}$$
$$B_{i,t}^{n} = B_{i,t}^{u} = B_{i,t}$$

Moreover, if we suppose that the cost of being employed is greater than the cost of being unemployed ($\Gamma^n > \Gamma^u$), the consumption of employed households is greater than consumption of unemployed ones($C_{i,t}^{n} > C_{i,t}^{u}$) and the first order condition becomes:

$$C_{it}^{n} = C_{it}^{u} - \Gamma^{u} + \Gamma^{n}$$

with full-insurance, $A_{i,t} = w_{i,t} + \Gamma^{u} - \Gamma^{n}$.

7.3 Appendix C: Figures

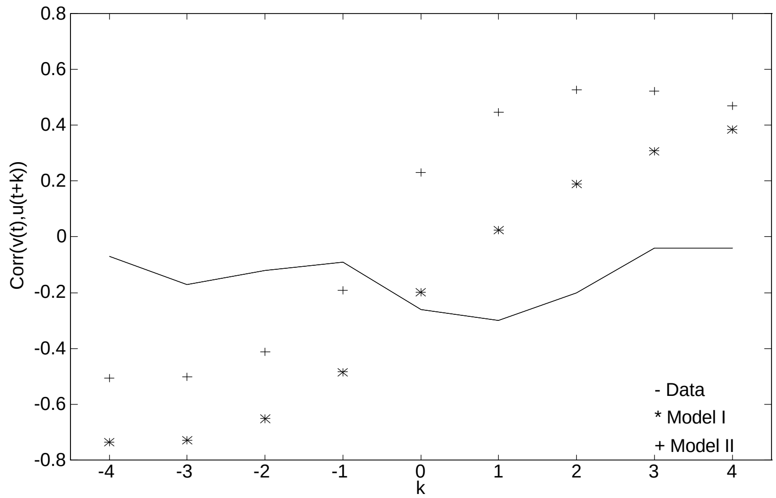

Fig 1. Beveridge Curve

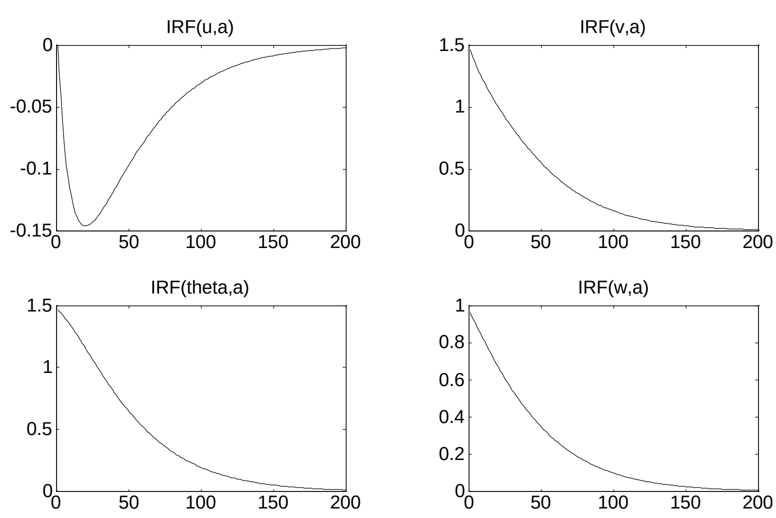

Fig 2. IRF to a Technological Shock

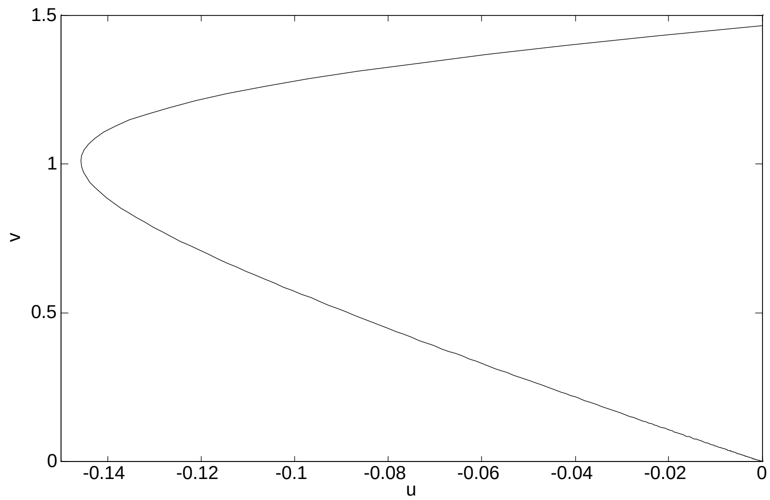

Fig 3. Dynamics of the Beveridge curve

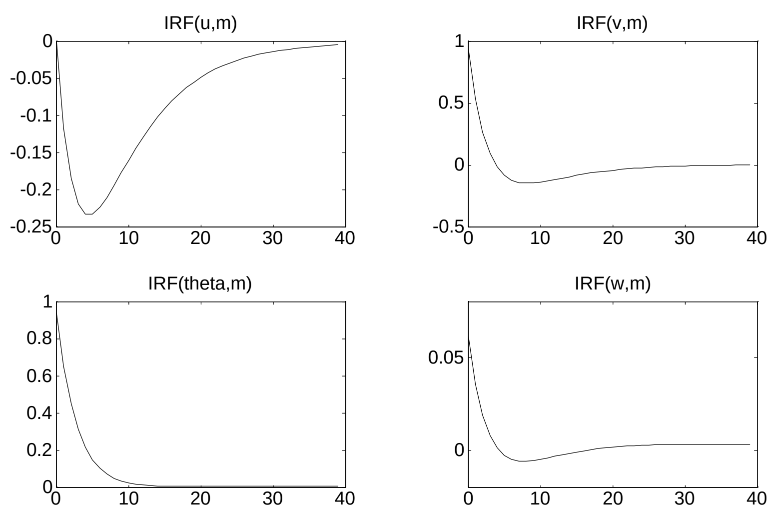

Fig 4. IRF to a Reallocation Shock